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ABSTRACT

Ways in which the Statistical Package for the Social Sciences (SPSS) can be used to perform some Rasch analyses are described in detail. It is shown how SPSS and a set of item calibrations can be used to estimate person abilities, standard errors of measurement, test characteristic curve, test information curve, classification consistency on a mastery test, and item and person fit statistics. Additional uses of SPSS are suggested. Figures, tables, and sample printouts of Rasch analyses using SPSC are appended. (GDC)

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RASCH ANALYSIS USING SPSS

BY

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INTRODUCTION

This paper describes how the Statistical Package for the Social Sciences (SPSS) can be used to perform several Rasch analyses. All that is needed for these procedures is a set of previously calibrated items. When this is the case, SPSS can be used to

1. estimate person abilities, b_r,
2. provide standard errors of ability, SE (b_r),
3. graph item characteristic curves, item information curves, the test characteristic curve (TCC), and the test information curve (TIC),
4. estimate classification consistency indices on mastery tests, and
5. calculate item and person fit statistics.

This paper is written with the assumption that the reader is familiar with the Rasch model (Wright and Stone, 1979), and SPSS (Nie, 1975). It is felt that this paper serves at least two useful purposes. First, since SPSS is on line in almost every computer installation, it makes some Rasch analyses available to researchers who do not have access to computer programs, such as BICAL (Wright and Mead, 1976). Second, the paper assists in understanding the underlying mathematics of Rasch analysis. Graphing and programming in SPSS helps to reveal the simplicity and elegance of the Rasch model.

ESTIMATING PERSON ABILITY AND STANDARD ERRORS

The Rasch model equation (or test characteristic curve) which describes the relationship between the test raw score, r, and the underlying ability, b_r, is

$$r = \sum_{i=1}^{L} \left[\frac{e^{(b_r - d_i)}}{1 + e^{(b_r - d_i)}} \right] . \qquad (1)$$

where r= the person's score, for r=1,1..,L-1,

L= the number of items on the test,

b_r= the person's ability associated with score r, and

d_i= the difficulty of item i, for i=1,2,..,L.

The problem with equation 1 is that even though d_i and r are known, the equation cannot be algebraically solved for b_r. The procedure most often used to solve equation 1 is to estimate b_r using Newton's iteration method. As an example, the BICAL computer program used the Newton iteration procedure to estimate the 42 ability values in column 1 of Table 2 from the 43 item difficulties in Table 1. However, almost identical estimates can be obtained by using SPSS (see column 3 of Table 2).

Appendix A contains the SPSS control cards needed to calculate the ability estimates in column 3 of Table 2. A brief description of these control cards may be useful in better understanding how SPSS can be used to obtain ability estimates from a set of calibrated items. The

important control cards in Appendix A are the COMPUTE statements in lines 8 to 105. Lines 8 to 50 use an input variable called BETA (i.e., b_r in equation 1). This variable will be described shortly. In Appendix A the following information is calculated solely from the 43 item calibrations in Table 1.

1. Lines 8-50: item characteristic curves for each of the 43 items.
2. Lines 51-55: the test characteristic curve.
3. Lines 57-99: item information curves.
4. Lines 100-104: the test information curve.
5. Line 105: the unbiased estimate of BETA
6. Line 106: the standard error of BETA.

The only input variable to SPSS are values of BETA. It may at first seem odd that we are inputing the values we are seeking to estimate, however, the purpose is quite simple. The TCC is actually a continuous function in which the logit scale ranges from minus to plus infinity and the raw score scale ranges from nearly zero to nearly L. The Newton iteration procedure attempts to find those values of b_r which are closely associated with integer values of the raw score scale. In SPSS we input a large number of BETA values then pick those values which are most closely associated with integer values of the raw score scale. In Appendix A the raw score scale is called TCC. In actuality, TCC is the ordinate of the test characteristic curve and BETA is the abscissa. The difference between the Newton iteration procedure and the SPSS procedure is that in the former the values of b_r are estimated analytically, whereas in the latter, the values of b_r are

selected by hand. In Table 2 the values of BETA obtained from SPSS were selected as follows:

1. 1401 values of the variable BETA (or cases in SPSS language) were input. These were values ranging from -7.00 to +7.00 with each value incremented by .01.
2. For each value of BETA, a value of TCC and SEMB (the standard error of measurement) were calculated and listed using the LIST CASES procedure.
3. The ability estimates and standard errors of measurement in columns 3 and 4, respectively, of Table 2 were obtained by choosing those 42 values of BETA most closely associated with integer values of TCC.
4. Once the appropriate 42 values of BETA were selected they were then input into a separate SPSS RUN (See Appendix B) which produced graphs of the test characteristic curve (figure 1), the test information curve (figure 2), and the standard error of measurement curve (figure 3).

CLASSIFICATION CONSISTENCY FOR MASTERY TESTS

If the 43 item test in Table 1 happens to be a mastery test then good reliability is indicated by high classification consistency on two parallel forms of the test. When this is the case, Subkoviak's (1976) method of reliability estimation can be readily adapted to the Rasch model. Although Subkoviak's indices are usually applied to the raw score metric, they may also be applied to the Rasch logit metric, b_i. In order to calculate Subkoviak's index of classification consistency

(PCC), let us assume that we have a cut-score of $b_r = .66$ which indicates mastery on the test. SPSS can be used to express the difference between .66 and each BETA as a standard normal deviate ZB with the COMPUTE statement in line 105 of Appendix B. Using the asymptotic sampling distribution of BETA (which is assumed to be normal), the probability of being classified as a master PM on the test is the proportion of the area under the normal curve above ZB. SPSS can be used to calculate areas under the normal curve with the COMPUTE statements in lines 105 to 111 of Appendix B. In these COMPUTE statements: ZB is the standard normal deviate of .66 under each BETA sampling distribution; FB is the height of the normal curve at ZB; and PM is the area under the normal curve above ZB (i.e., the probability of being classified a master). According to Subkoviak's formulations the probability of being consistently classified on two independent test administrations (PCC) is obtained in line 111 of Appendix B. For the 43 items the quantities PM and PCC are listed in Table 3, and graphed in figures 4 and 5, respectively.

To better understand the meaning of the quantities PM and PCC let us assume an examinee's true BETA value is .16. If this if the case, then the probability of this examinee scoring higher than .66 on the test (just by chance) is PM=.08. The probability that this examinee would be consistently classified on two independent administrations of this test is PCC=.86. We see that the values of PCC approach 1.00 as the examinees true ability is far above or below the cut-score. At the cut-score of .66, the probability of consistent classification is equal to .50.

ITEM AND PERSON FIT STATISTICS

SPSS can also be used to test item-and person-fit. Although no data on this procedure will be presented in this paper, the general procedure for accomplishing the task will be provided. For an example of how a fit analysis might be obtained let us say we input into SPSS the item responses of N examinees on each of the 43 items in Table 1. If the item responses are alphanumeric (e.g., A,B,C, and D), SPSS can convert them to numeric responses using the RECODE statements.

```
RECODE          Item1 to Item43 ('A'=1) ('B'=2) ('C'=3) ('D'=4)
```

SPSS can then grade the test, and convert each item response to a "1" if correct, and a "Ø" if incorrect. This can be done with the DO REPEAT statement in which the variable KEY indicates the answer key for the 43 items. For example,

```
DO REPEAT       ITEM=ITEM1 to ITEM43/
                KEY=1,3,4,2,2,2,1,4,3,2,
                    3,2,4,1,2,1,1,3,4,4,
                    2,3,4,3,3,2,2,1,2,4,
                    4,4,1,1,2,4,3,2,1,2,
                    1,2,3,/
IF              (ITEM NE KEY) ITEM=Ø
IF              (ITEM EQ KEY) ITEM=1
END REPEAT
```

With the above statements SPSS has now created an N-person by 43-item data matrix. A standardized residual for each element in the data matrix may be obtained by using equations from Wright and Stone (1979). For example, the standarized residual (Z1) for the first item in Table 1 may be obtained as follows

```
COMPUTE        P1=(EXP(BETA-(0.617)))/(1+EXP(BETA-(-0.617)))
COMPUTE        Z1=(ITEM1-P1)/(SQRT(P1*(1-P1)))
```

In an analogous manner we can also calculate Z2 to Z43. To calculate the misfit statistic for each person we sum the squared standardized residuals over each item and devide this sum by L-1. To calculate the misfit statistic for each item we sum the squared standardized residuals over each person and devide this sum by N-1. According to Wright and Stone (1979) the person misfit statistic has an approximate F-distribution with degrees of freedom equal to L-1, and infinity. Similarly, the item misfit statistic has an approximate F-distribution with degrees of freedom equal to N-1 and infinity.

SUMMARY AND DISCUSSION

This paper provided the details of procedures whereby the SPSS can be used to perform some Rasch analyses. More specifically, it was shown how SPSS, and a set of item calibrations can be used to: estimate person abilities; standard errors of measurement; the test characteristic curve; the test information curve; classification consistency on a mastery test; and item and person fit statistics.

There are other Rasch analysis procedures that can be performed by SPSS. They were not covered in this paper because they are less relevant. However, they should be briefly mentioned. For example, the discrimination index provided by BICAL can be obtained by SPSS. As an example of this, the discrimination index for ITEM1 may be calculated by correlating (ITEM1-P1) with BETA, then adding 1 to the obtained

correlation. In this case ITEM1 equals one if answered correctly and equals zero if answered incorrectly. Also, the KR-20 reported on BICAL can be obtained by using the SPSS procedure called RELIABILITY , and of course the point biserial correlations can be obtained with the SPSS procedure called PEARSON CORR.

Finally, it should be noted that SPSS can be used to graph and calculate many quantities used with the three parameter logistic model. All that is needed are the three item parameters (difficulty, discrimination, and guessing), and the ability estimates for each person.

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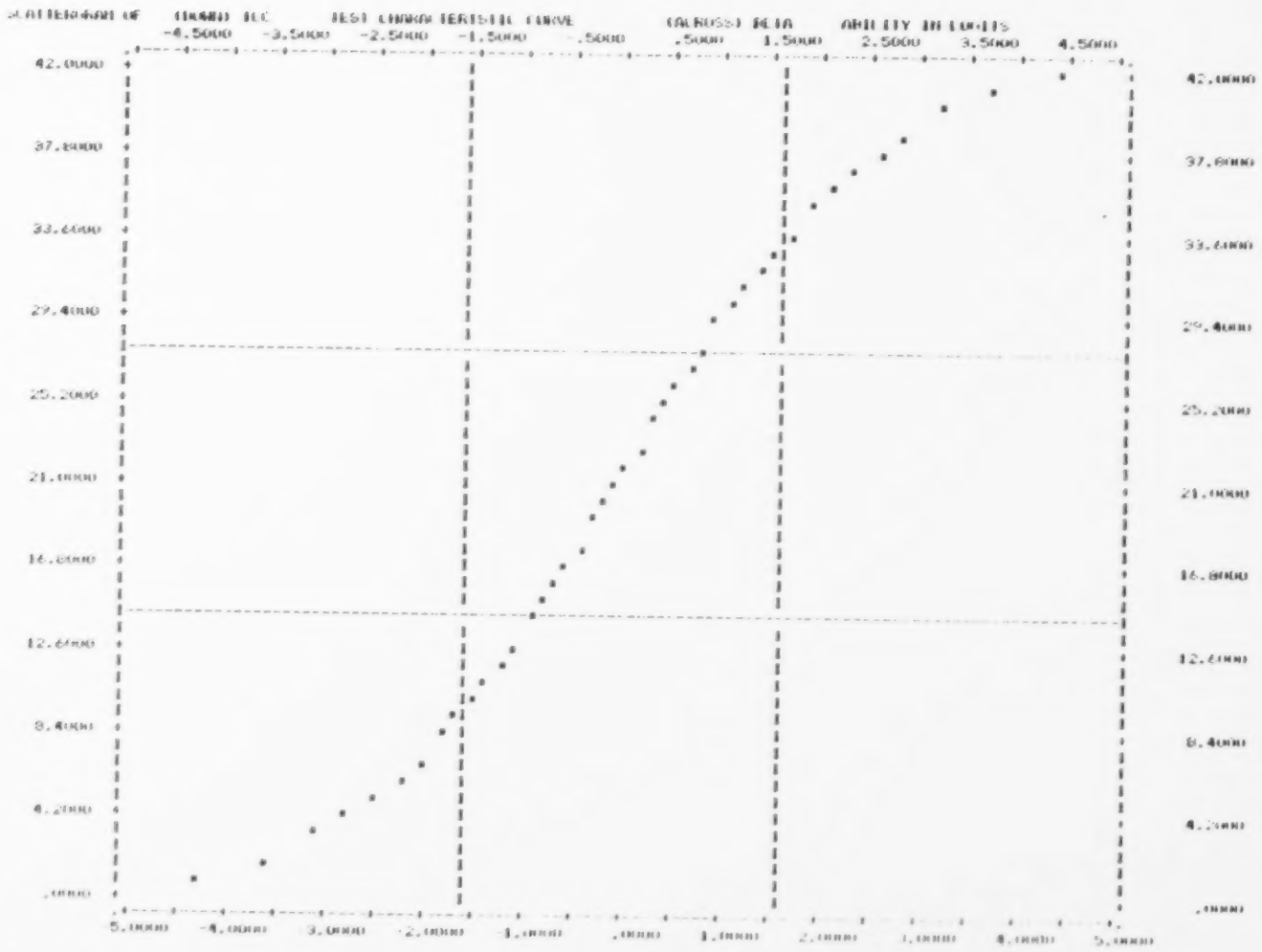

Figure 1: SPSS graph of Test Characteristic Curve

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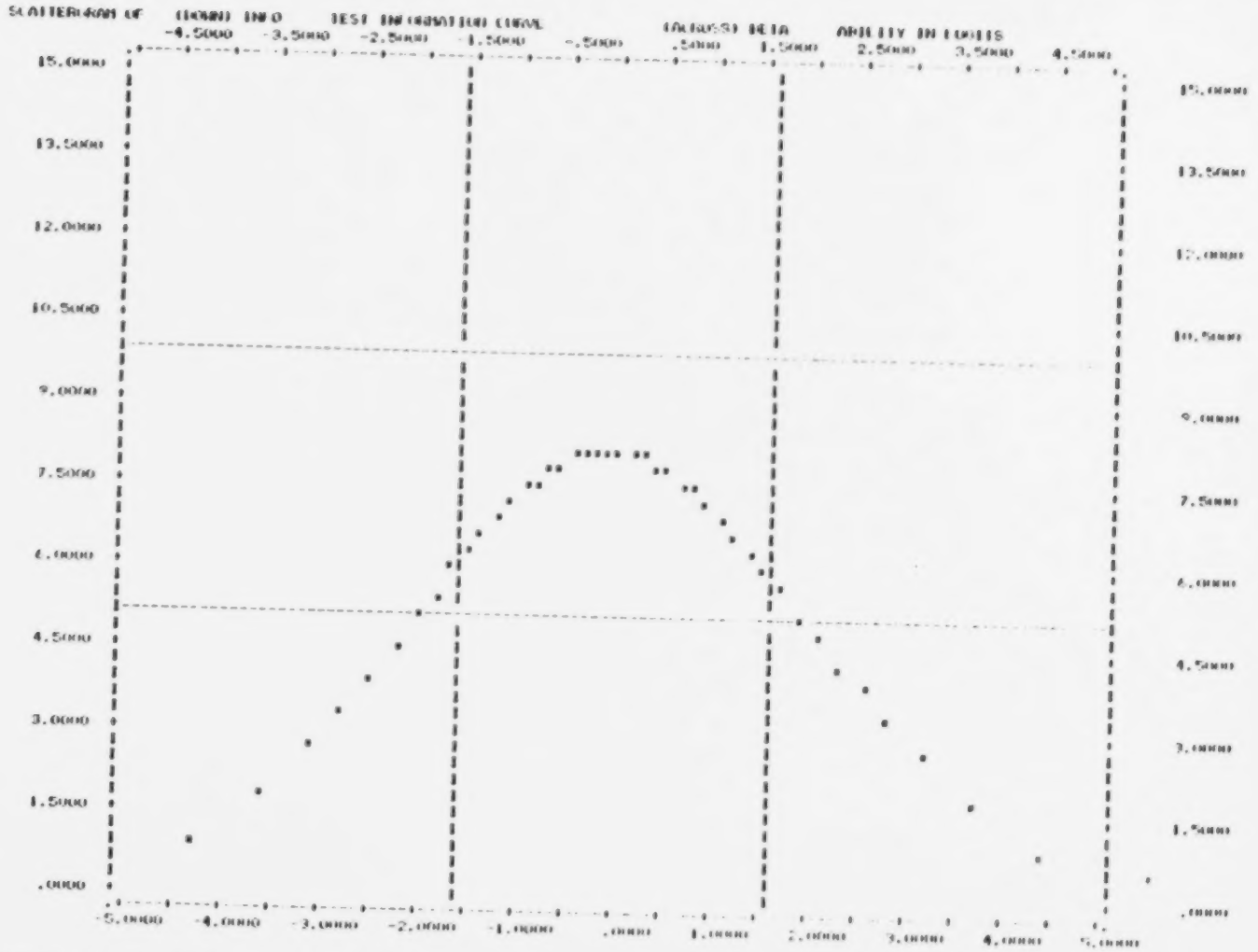

Figure 2: SPSS graph of Test Information Curve

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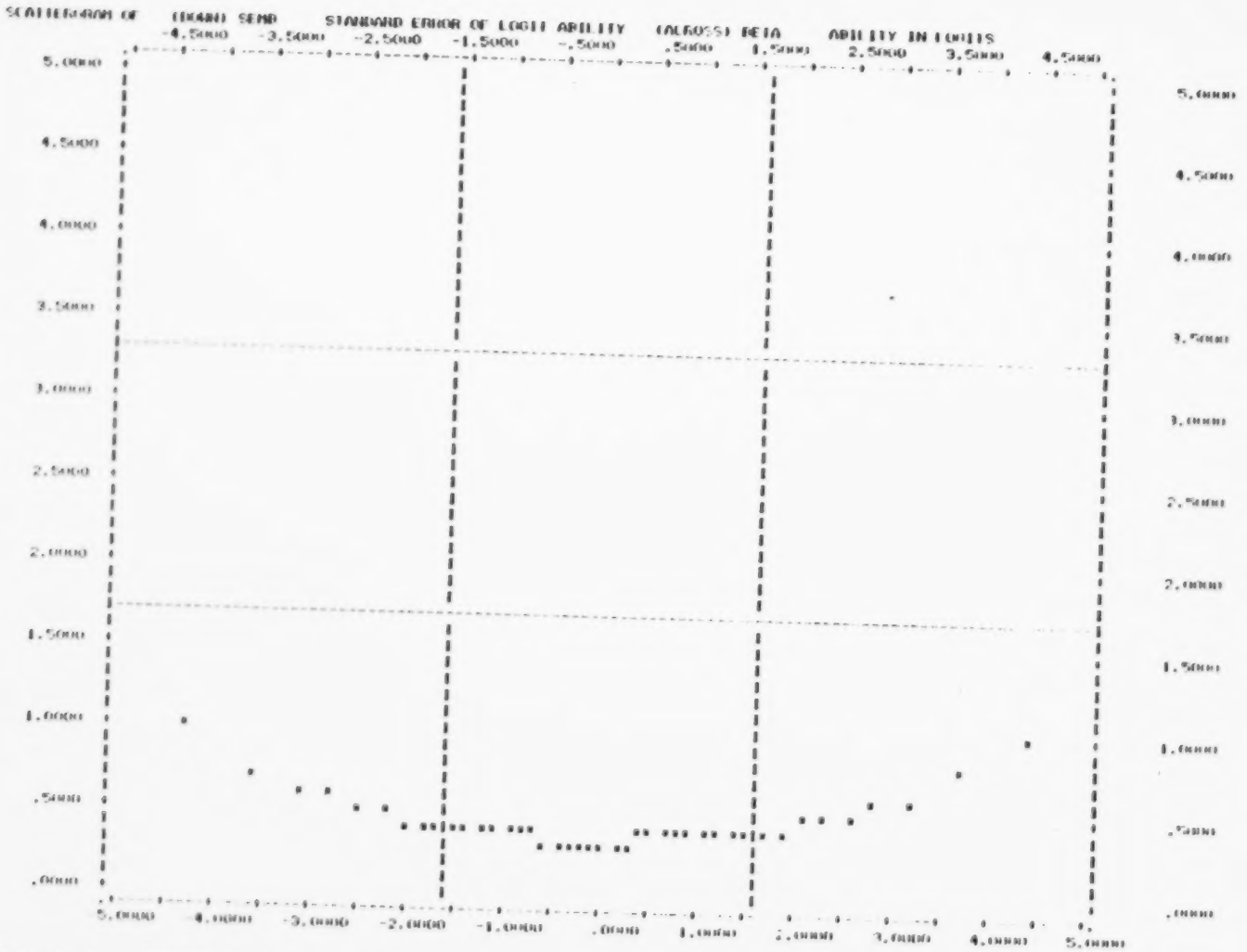

Figure 3: SPSS graph of Standard Error of Measurement Curve

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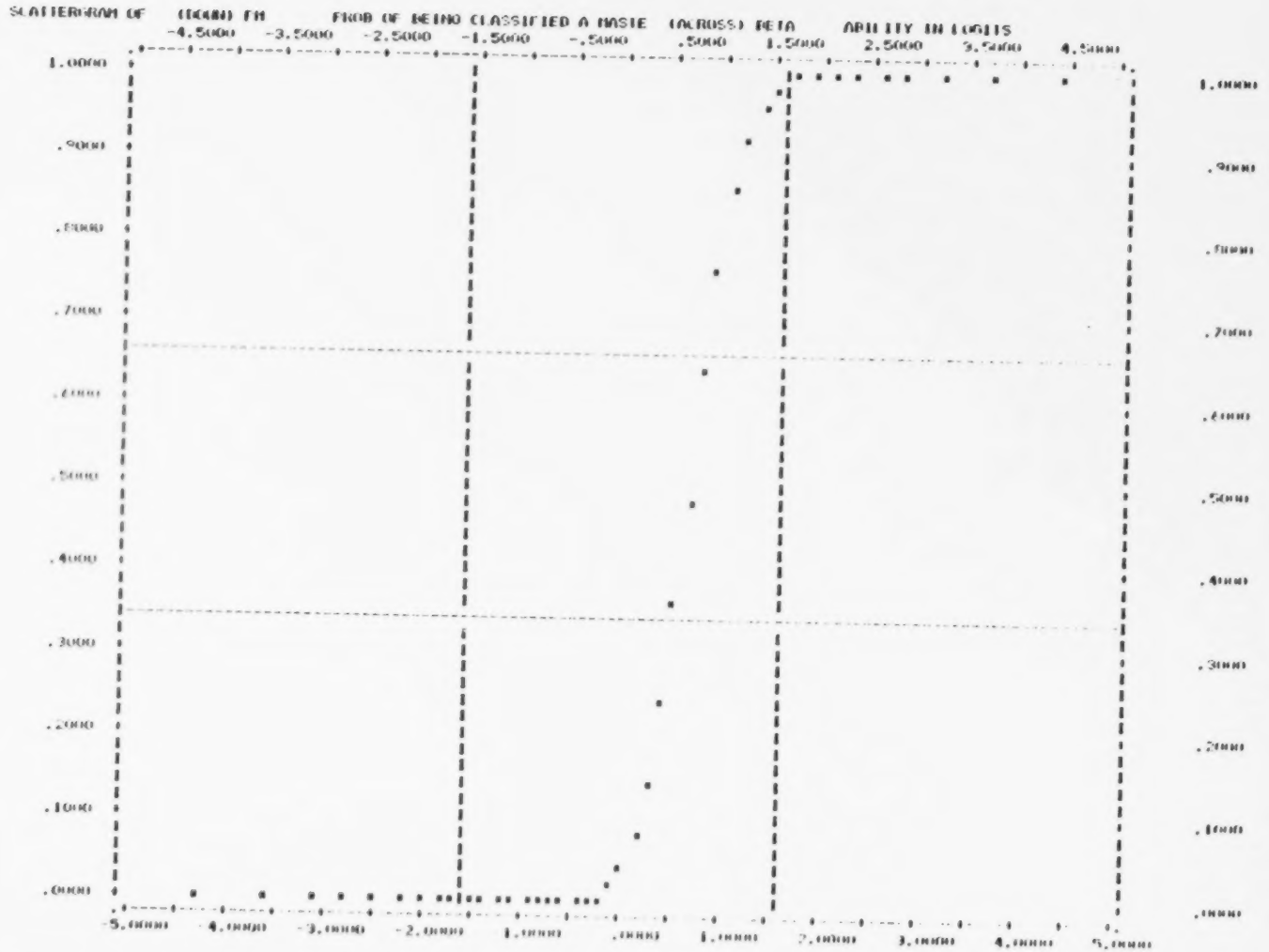

Figure 4: SPSS graph of the probability of being classified a master for each true score BETA

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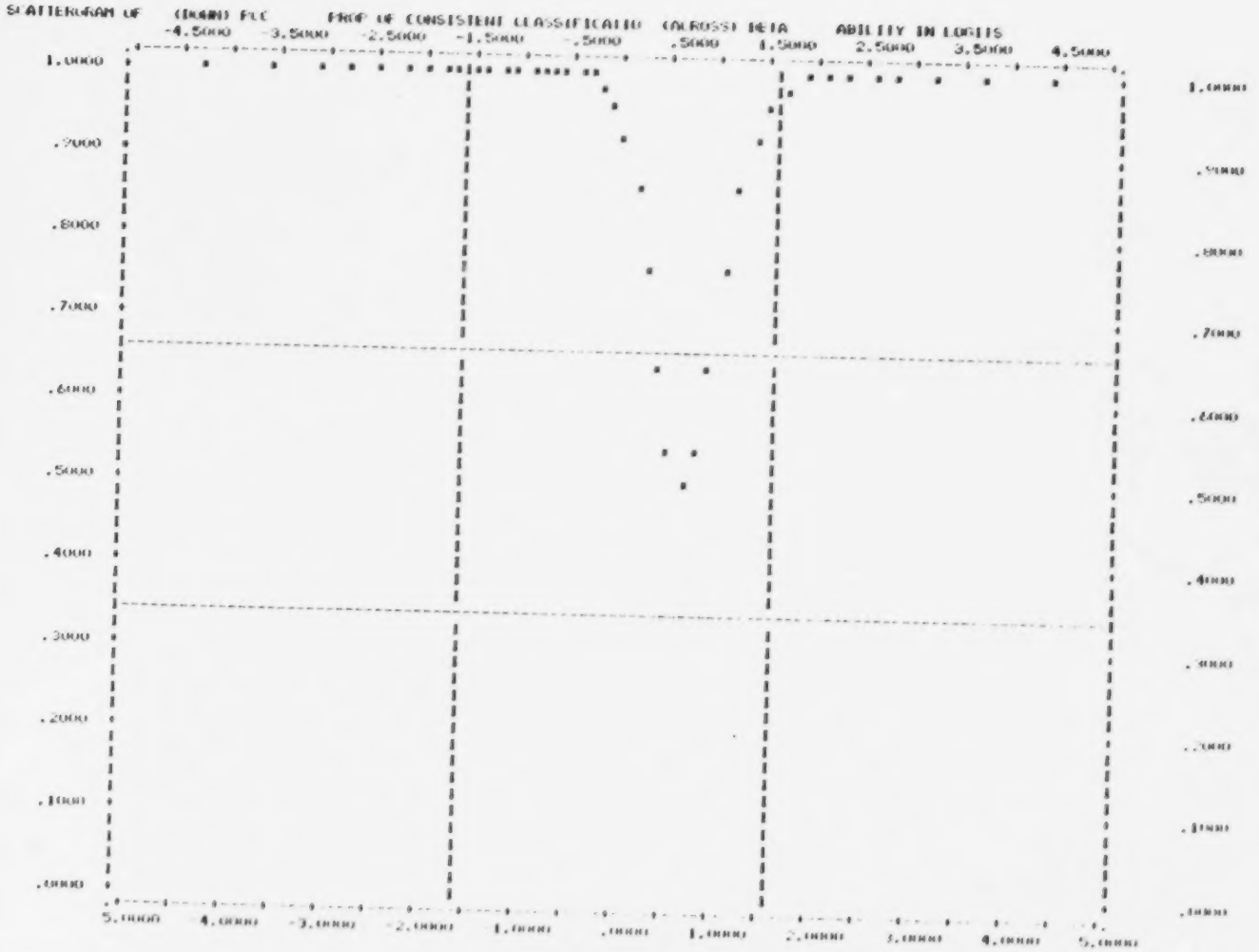

Figure 5: SPSS graph of the probability of being consistently classified for each true score BETA

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Table 1

Rasch item calibrations
for 43 items

-0.617
-0.439
-2.028
1.593
1.393
0.463
-1.265
2.103
-0.439
0.286
-0.280
0.159
1.095
-1.925
-0.365
1.257
-0.172
0.126
-2.787
-1.323
-1.975
-0.762
-1.549
-0.617
-0.600
-0.670
0.444
-1.083
0.919
0.036
0.760
-0.743
0.047
-0.600
-0.670
1.814
1.785
-0.322
2.014
3.365
-0.881
1.851
0.602

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Table 2

Ability estimates and standard errors (SE) estimated by BICAL and SPSS

BICAL		SPSS	
Ability	SE	Ability	SE
-4.31	1.02	-4.30	1.03
-3.57	.74	-3.56	.75
-3.11	.63	-3.10	.63
-2.77	.56	-2.76	.56
-2.49	.51	-2.48	.51
-2.25	.47	-2.25	.48
-2.05	.45	-2.04	.45
-1.86	.43	-1.85	.43
-1.68	.41	-1.68	.41
-1.52	.40	-1.51	.40
-1.37	.39	-1.37	.39
-1.23	.38	-1.22	.38
-1.09	.37	-1.08	.37
-.96	.37	-.95	.37
-.83	.36	-.82	.36
-.70	.36	-.69	.36
-.58	.35	-.57	.35
-.45	.35	-.45	.35
-.33	.35	-.32	.35
-.21	.35	-.21	.35
-.09	.35	-.08	.35
.03	.35	.04	.35
.15	.35	.16	.35
.27	.35	.28	.35
.39	.36	.40	.36
.52	.36	.53	.36
.65	.36	.65	.36
.78	.37	.79	.37
.91	.37	.93	.37
1.05	.38	1.06	.38
1.20	.39	1.21	.39
1.35	.40	1.36	.40
1.51	.41	1.52	.41
1.68	.43	1.69	.42
1.87	.44	1.87	.44
2.07	.46	2.08	.46
2.29	.48	2.29	.49
2.54	.53	2.55	.52
2.83	.57	2.84	.57
3.19	.64	3.19	.64
3.67	.77	3.68	.77
4.44	1.04	4.44	1.05

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TABLE 3

Ability, standard error of measurement, test characteristic curve, test information curve, probability of mastery classification, and probability of consistent classification estimated with SPSS

CASE-N	BETA	SEMB	TCC	INFO	PM	PCC
1	-4.30	1.03	1.00	1.03	.00	1.00
2	-3.56	.75	2.00	1.89	.00	1.00
3	-3.10	.63	3.00	2.66	.00	1.00
4	-2.76	.56	4.00	3.35	.00	1.00
5	-2.48	.51	5.00	3.97	.00	1.00
6	-2.25	.48	6.00	4.52	.00	1.00
7	-2.04	.45	7.00	5.04	.00	1.00
8	-1.85	.43	8.00	5.51	.00	1.00
9	-1.68	.41	9.00	5.92	.00	1.00
10	-1.51	.40	10.00	6.32	.00	1.00
11	-1.37	.39	11.00	6.64	.00	1.00
12	-1.22	.38	12.00	6.95	.00	1.00
13	-1.08	.37	13.00	7.22	.00	1.00
14	-.95	.37	14.00	7.45	.00	1.00
15	-.82	.36	15.00	7.64	.00	1.00
16	-.69	.36	16.00	7.81	.00	1.00
17	-.57	.35	17.00	7.94	.00	1.00
18	-.45	.35	18.00	8.03	.00	1.00
19	-.32	.35	19.00	8.10	.00	.99
20	-.21	.35	20.00	8.14	.01	.99
21	-.08	.35	21.00	8.14	.02	.97
22	.04	.35	22.00	8.11	.04	.93
23	.16	.35	23.00	8.06	.08	.86
24	.28	.35	24.00	7.98	.14	.76
25	.40	.36	25.00	7.87	.24	.64
26	.53	.36	26.00	7.73	.36	.54
27	.65	.36	27.00	7.58	.49	.50
28	.79	.37	28.00	7.37	.64	.54
29	.93	.37	29.00	7.15	.77	.64
30	1.06	.38	30.00	6.92	.85	.75
31	1.21	.39	31.00	6.63	.92	.85
32	1.36	.40	32.00	6.34	.96	.92
33	1.52	.41	33.00	6.00	.98	.96
34	1.69	.42	34.00	5.64	.99	.99
35	1.87	.44	35.00	5.24	1.00	.99
36	2.08	.46	36.00	4.78	1.00	1.00
37	2.29	.49	37.00	4.32	1.00	1.00
38	2.55	.52	38.00	3.77	1.00	1.00
39	2.84	.57	39.00	3.19	1.00	1.00
40	3.19	.64	40.00	2.55	1.00	1.00
41	3.68	.77	41.00	1.82	1.00	1.00
42	4.44	1.05	42.00	1.00	1.00	1.00

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APPENDIX A

```
 1      PRINT BACK       NO
 2      FILE NAME        RASCH ANALYSIS USING SPSS
 3      ALLOCATE         TRANSPACE=15000
 4      VARIABLE LIST    BETA
 5      INPUT FORMAT     FIXED(X,F5.2)
 6      INPUT MEDIUM     DISC
 7      N OF CASES       UNKNOWN
 8      COMPUTE           P1=(EXP(BETA-(-0.617)))/(1+EXP(BETA-(-0.617)))
 9      COMPUTE           P2=(EXP(BETA-(-0.439)))/(1+EXP(BETA-(-0.439)))
10      COMPUTE           P3=(EXP(BETA-(-2.028)))/(1+EXP(BETA-(-2.028)))
11      COMPUTE           P4=(EXP(BETA-( 1.593)))/(1+EXP(BETA-( 1.593)))
12      COMPUTE           P5=(EXP(BETA-( 1.393)))/(1+EXP(BETA-( 1.393)))
13      COMPUTE           P6=(EXP(BETA-( 0.463)))/(1+EXP(BETA-( 0.463)))
14      COMPUTE           P7=(EXP(BETA-(-1.265)))/(1+EXP(BETA-(-1.265)))
15      COMPUTE           P8=(EXP(BETA-( 2.107)))/(1+EXP(BETA-( 2.107)))
16      COMPUTE           P9=(EXP(BETA-(-0.439)))/(1+EXP(BETA-(-0.439)))
17      COMPUTE          P10=(EXP(BETA-( 0.286)))/(1+EXP(BETA-( 0.286)))
18      COMPUTE          P11=(EXP(BETA-( 0.280)))/(1+EXP(BETA-( 0.280)))
19      COMPUTE          P12=(EXP(BETA-( 0.159)))/(1+EXP(BETA-( 0.159)))
20      COMPUTE          P13=(EXP(BETA-( 1.095)))/(1+EXP(BETA-( 1.095)))
21      COMPUTE          P14=(EXP(BETA-(-1.925)))/(1+EXP(BETA-(-1.925)))
22      COMPUTE          P15=(EXP(BETA-(-0.365)))/(1+EXP(BETA-(-0.365)))
23      COMPUTE          P16=(EXP(BETA-( 1.257)))/(1+EXP(BETA-( 1.257)))
24      COMPUTE          P17=(EXP(BETA-(-0.172)))/(1+EXP(BETA-(-0.172)))
25      COMPUTE          P18=(EXP(BETA-( 0.126)))/(1+EXP(BETA-( 0.126)))
26      COMPUTE          P19=(EXP(BETA-(-2.787)))/(1+EXP(BETA-(-2.787)))
27      COMPUTE          P20=(EXP(BETA-(-1.323)))/(1+EXP(BETA-(-1.323)))
28      COMPUTE          P21=(EXP(BETA-(-1.975)))/(1+EXP(BETA-(-1.975)))
29      COMPUTE          P22=(EXP(BETA-(-0.762)))/(1+EXP(BETA-(-0.762)))
30      COMPUTE          P23=(EXP(BETA-(-1.549)))/(1+EXP(BETA-(-1.549)))
31      COMPUTE          P24=(EXP(BETA-(-0.617)))/(1+EXP(BETA-(-0.617)))
32      COMPUTE          P25=(EXP(BETA-(-0.600)))/(1+EXP(BETA-(-0.600)))
33      COMPUTE          P26=(EXP(BETA-(-0.670)))/(1+EXP(BETA-(-0.670)))
34      COMPUTE          P27=(EXP(BETA-( 0.444)))/(1+EXP(BETA-( 0.444)))
35      COMPUTE          P28=(EXP(BETA-(-1.083)))/(1+EXP(BETA-(-1.083)))
36      COMPUTE          P29=(EXP(BETA-( 0.919)))/(1+EXP(BETA-( 0.919)))
37      COMPUTE          P30=(EXP(BETA-( 0.036)))/(1+EXP(BETA-( 0.036)))
38      COMPUTE          P31=(EXP(BETA-( 0.760)))/(1+EXP(BETA-( 0.760)))
39      COMPUTE          P32=(EXP(BETA-(-0.743)))/(1+EXP(BETA-(-0.743)))
40      COMPUTE          P33=(EXP(BETA-( 0.047)))/(1+EXP(BETA-( 0.047)))
41      COMPUTE          P34=(EXP(BETA-(-0.600)))/(1+EXP(BETA-(-0.600)))
42      COMPUTE          P35=(EXP(BETA-(-0.670)))/(1+EXP(BETA-(-0.670)))
43      COMPUTE          P36=(EXP(BETA-( 1.814)))/(1+EXP(BETA-( 1.814)))
44      COMPUTE          P37=(EXP(BETA-( 1.785)))/(1+EXP(BETA-( 1.785)))
45      COMPUTE          P38=(EXP(BETA-(-0.322)))/(1+EXP(BETA-(-0.322)))
46      COMPUTE          P39=(EXP(BETA-( 2.014)))/(1+EXP(BETA-( 2.014)))
47      COMPUTE          P40=(EXP(BETA-( 3.365)))/(1+EXP(BETA-( 3.365)))
48      COMPUTE          P41=(EXP(BETA-(-0.881)))/(1+EXP(BETA-(-0.881)))
49      COMPUTE          P42=(EXP(BETA-( 1.851)))/(1+EXP(BETA-( 1.851)))
50      COMPUTE          P43=(EXP(BETA-( 0.602)))/(1+EXP(BETA-( 0.602)))
```

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```
COMPUTE         TCC=(P1+P2+P3+P4+P5+P6+P7+P8+P9+P10+P11+P12
                   +P13+P14+P15+P16+P17+P18+P19+P20+P21+P22
                   +P23+P24+P25+P26+P27+P28+P29+P30+P31+P32
                   +P33+P34+P35+P36+P37+P38+P39+P40+P41+P42
                   +P43)
COMPUTE         L=43.0
COMPUTE         I1=P1*(1-P1)
COMPUTE         I2=P2*(1-P2)
COMPUTE         I3=P3*(1-P3)
COMPUTE         I4=P4*(1-P4)
COMPUTE         I5=P5*(1-P5)
COMPUTE         I6=P6*(1-P6)
COMPUTE         I7=P7*(1-P7)
COMPUTE         I8=P8*(1-P8)
COMPUTE         I9=P9*(1-P9)
COMPUTE         I10=P10*(1-P10)
COMPUTE         I11=P11*(1-P11)
COMPUTE         I12=P12*(1-P12)
COMPUTE         I13=P13*(1-P13)
COMPUTE         I14=P14*(1-P14)
COMPUTE         I15=P15*(1-P15)
COMPUTE         I16=P16*(1-P16)
COMPUTE         I17=P17*(1-P17)
COMPUTE         I18=P18*(1-P18)
COMPUTE         I19=P19*(1-P19)
COMPUTE         I20=P20*(1-P20)
COMPUTE         I21=P21*(1-P21)
COMPUTE         I22=P22*(1-P22)
COMPUTE         I23=P23*(1-P23)
COMPUTE         I24=P24*(1-P24)
COMPUTE         I25=P25*(1-P25)
COMPUTE         I26=P26*(1-P26)
COMPUTE         I27=P27*(1-P27)
COMPUTE         I28=P28*(1-P28)
COMPUTE         I29=P29*(1-P29)
COMPUTE         I30=P30*(1-P30)
COMPUTE         I31=P31*(1-P31)
COMPUTE         I32=P32*(1-P32)
COMPUTE         I33=P33*(1-P33)
COMPUTE         I34=P34*(1-P34)
COMPUTE         I35=P35*(1-P35)
COMPUTE         I36=P36*(1-P36)
COMPUTE         I37=P37*(1-P37)
COMPUTE         I38=P38*(1-P38)
COMPUTE         I39=P39*(1-P39)
COMPUTE         I40=P40*(1-P40)
COMPUTE         I41=P41*(1-P41)
COMPUTE         I42=P42*(1-P42)
COMPUTE         I43=P43*(1-P43)
COMPUTE         INFO=I1+I2+I3+I4+I5+I6+I7+I8+I9+I10+I11+I12
                   +I13+I14+I15+I16+I17+I18+I19+I20+I21+I22
                   +I23+I24+I25+I26+I27+I28+I29+I30+I31+I32
                   +I33+I34+I35+I36+I37+I38+I39+I40+I41+I42
                   +I43
COMPUTE         BETA=BETA*((L-2)/(L-1))
COMPUTE         SEMB=SQRT(1/INFO)
PRINT FORMATS   TCC,BETA,SEMB(2)
LIST CASES      CASES=2000/VARIABLES=TCC,BETA,SEMB/
READ INPUT DATA
```


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APPENDIX B

```
  1      PRINT BACK       NO
  2      FILE NAME        RASCH ANALYSIS USING SPSS
  3      ALLOCATE         TRANSPACE=15000
  4      VARIABLE LIST    BETA,SEMB
  5      INPUT FORMAT     FIXED(25X,F5.2,T36,F4.2)
  6      INPUT MEDIUM     DISC
  7      N OF CASES       UNKNOWN
  8      COMPUTE           P1=(EXP(BETA-(-0.617)))/(1+EXP(BETA-(-0.617)))
  9      COMPUTE           P2=(EXP(BETA-(-0.439)))/(1+EXP(BETA-(-0.439)))
 10      COMPUTE           P3=(EXP(BETA-(-2.028)))/(1+EXP(BETA-(-2.028)))
 11      COMPUTE           P4=(EXP(BETA-( 1.593)))/(1+EXP(BETA-( 1.593)))
 12      COMPUTE           P5=(EXP(BETA-( 1.393)))/(1+EXP(BETA-( 1.393)))
 13      COMPUTE           P6=(EXP(BETA-( 0.463)))/(1+EXP(BETA-( 0.463)))
 14      COMPUTE           P7=(EXP(BETA-(-1.265)))/(1+EXP(BETA-(-1.265)))
 15      COMPUTE           P8=(EXP(BETA-( 2.107)))/(1+EXP(BETA-( 2.107)))
 16      COMPUTE           P9=(EXP(BETA-(-0.439)))/(1+EXP(BETA-(-0.439)))
 17      COMPUTE          P10=(EXP(BETA-( 0.286)))/(1+EXP(BETA-( 0.286)))
 18      COMPUTE          P11=(EXP(BETA-( 0.280)))/(1+EXP(BETA-( 0.280)))
 19      COMPUTE          P12=(EXP(BETA-( 0.159)))/(1+EXP(BETA-( 0.159)))
 20      COMPUTE          P13=(EXP(BETA-( 1.095)))/(1+EXP(BETA-( 1.095)))
 21      COMPUTE          P14=(EXP(BETA-(-1.925)))/(1+EXP(BETA-(-1.925)))
 22      COMPUTE          P15=(EXP(BETA-(-0.365)))/(1+EXP(BETA-(-0.365)))
 23      COMPUTE          P16=(EXP(BETA-( 1.257)))/(1+EXP(BETA-( 1.257)))
 24      COMPUTE          P17=(EXP(BETA-(-0.172)))/(1+EXP(BETA-(-0.172)))
 25      COMPUTE          P18=(EXP(BETA-( 0.126)))/(1+EXP(BETA-( 0.126)))
 26      COMPUTE          P19=(EXP(BETA-(-2.787)))/(1+EXP(BETA-(-2.787)))
 27      COMPUTE          P20=(EXP(BETA-(-1.323)))/(1+EXP(BETA-(-1.323)))
 28      COMPUTE          P21=(EXP(BETA-(-1.975)))/(1+EXP(BETA-(-1.975)))
 29      COMPUTE          P22=(EXP(BETA-(-0.762)))/(1+EXP(BETA-(-0.762)))
 30      COMPUTE          P23=(EXP(BETA-(-1.549)))/(1+EXP(BETA-(-1.549)))
 31      COMPUTE          P24=(EXP(BETA-(-0.617)))/(1+EXP(BETA-(-0.617)))
 32      COMPUTE          P25=(EXP(BETA-(-0.600)))/(1+EXP(BETA-(-0.600)))
 33      COMPUTE          P26=(EXP(BETA-(-0.670)))/(1+EXP(BETA-(-0.670)))
 34      COMPUTE          P27=(EXP(BETA-( 0.444)))/(1+EXP(BETA-( 0.444)))
 35      COMPUTE          P28=(EXP(BETA-(-1.083)))/(1+EXP(BETA-(-1.083)))
 36      COMPUTE          P29=(EXP(BETA-( 0.919)))/(1+EXP(BETA-( 0.919)))
 37      COMPUTE          P30=(EXP(BETA-( 0.036)))/(1+EXP(BETA-( 0.036)))
 38      COMPUTE          P31=(EXP(BETA-( 0.760)))/(1+EXP(BETA-( 0.760)))
 39      COMPUTE          P32=(EXP(BETA-(-0.743)))/(1+EXP(BETA-(-0.743)))
 40      COMPUTE          P33=(EXP(BETA-( 0.047)))/(1+EXP(BETA-( 0.047)))
 41      COMPUTE          P34=(EXP(BETA-(-0.600)))/(1+EXP(BETA-(-0.600)))
 42      COMPUTE          P35=(EXP(BETA-(-0.670)))/(1+EXP(BETA-(-0.670)))
 43      COMPUTE          P36=(EXP(BETA-( 1.814)))/(1+EXP(BETA-( 1.814)))
 44      COMPUTE          P37=(EXP(BETA-( 1.785)))/(1+EXP(BETA-( 1.785)))
 45      COMPUTE          P38=(EXP(BETA-(-0.322)))/(1+EXP(BETA-(-0.322)))
 46      COMPUTE          P39=(EXP(BETA-( 2.014)))/(1+EXP(BETA-( 2.014)))
 47      COMPUTE          P40=(EXP(BETA-( 3.365)))/(1+EXP(BETA-( 3.365)))
 48      COMPUTE          P41=(EXP(BETA-(-0.881)))/(1+EXP(BETA-(-0.881)))
 49      COMPUTE          P42=(EXP(BETA-( 1.851)))/(1+EXP(BETA-( 1.851)))
 50      COMPUTE          P43=(EXP(BETA-( 0.602)))/(1+EXP(BETA-( 0.602)))
```


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APPENDIX B (CONT.)

```
 51      COMPUTE         TCC=RND(P1+P2+P3+P4+P5+P6+P7+P8+P9+P10+P11+P12
 52                         +P13+P14+P15+P16+P17+P18+P19+P20+P21+P22
 53                         +P23+P24+P25+P26+P27+P28+P29+P30+P31+P32
 54                         +P33+P34+P35+P36+P37+P38+P39+P40+P41+P42
 55                         +P43)
 56      COMPUTE         L=43.0
 57      COMPUTE         I1=P1*(1-P1)
 58      COMPUTE         I2=P2*(1-P2)
 59      COMPUTE         I3=P3*(1-P3)
 60      COMPUTE         I4=P4*(1-P4)
 61      COMPUTE         I5=P5*(1-P5)
 62      COMPUTE         I6=P6*(1-P6)
 63      COMPUTE         I7=P7*(1-P7)
 64      COMPUTE         I8=P8*(1-P8)
 65      COMPUTE         I9=P9*(1-P9)
 66      COMPUTE         I10=P10*(1-P10)
 67      COMPUTE         I11=P11*(1-P11)
 68      COMPUTE         I12=P12*(1-P12)
 69      COMPUTE         I13=P13*(1-P13)
 70      COMPUTE         I14=P14*(1-P14)
 71      COMPUTE         I15=P15*(1-P15)
 72      COMPUTE         I16=P16*(1-P16)
 73      COMPUTE         I17=P17*(1-P17)
 74      COMPUTE         I18=P18*(1-P18)
 75      COMPUTE         I19=P19*(1-P19)
 76      COMPUTE         I20=P20*(1-P20)
 77      COMPUTE         I21=P21*(1-P21)
 78      COMPUTE         I22=P22*(1-P22)
 79      COMPUTE         I23=P23*(1-P23)
 80      COMPUTE         I24=P24*(1-P24)
 81      COMPUTE         I25=P25*(1-P25)
 82      COMPUTE         I26=P26*(1-P26)
 83      COMPUTE         I27=P27*(1-P27)
 84      COMPUTE         I28=P28*(1-P28)
 85      COMPUTE         I29=P29*(1-P29)
 86      COMPUTE         I30=P30*(1-P30)
 87      COMPUTE         I31=P31*(1-P31)
 88      COMPUTE         I32=P32*(1-P32)
 89      COMPUTE         I33=P33*(1-P33)
 90      COMPUTE         I34=P34*(1-P34)
 91      COMPUTE         I35=P35*(1-P35)
 92      COMPUTE         I36=P36*(1-P36)
 93      COMPUTE         I37=P37*(1-P37)
 94      COMPUTE         I38=P38*(1-P38)
 95      COMPUTE         I39=P39*(1-P39)
 96      COMPUTE         I40=P40*(1-P40)
 97      COMPUTE         I41=P41*(1-P41)
 98      COMPUTE         I42=P42*(1-P42)
 99      COMPUTE         I43=P43*(1-P43)
100      COMPUTE         INFO=I1+I2+I3+I4+I5+I6+I7+I8+I9+I10+I11+I12
```


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APPENDIX B (CONT.)

```
101                                 +I13+I14+I15+I16+I17+I18+I19+I20+I21+I22
102                                 +I23+I24+I25+I26+I27+I28+I29+I30+I31+I32
103                                 +I33+I34+I35+I36+I37+I38+I39+I40+I41+I42
104                                 +I43
105     COMPUTE             ZB=((.66-BETA)/SEMB)
106     COMPUTE             FB=(EXP((-ZB**2)/2)/2.5066232746)
107     COMPUTE             YB=ZB
108     COMPUTE             YB=1/(1+(.33267*(ABS(YB))))
109     COMPUTE             PM=(FB*((.4361836*YB)+(-.1201676*(YB**2))+(.937298*
110                         (YB**3))))
111     IF                  (ZB LE 0.0) PM=1-PM
112     COMPUTE             PCC=(PM**2)+((1-PM)**2)
113     VAR LABELS          TCC  TEST CHARACTERISTIC CURVE/
114     VAR LABELS          INFO TEST INFORMATION CURVE/
115     VAR LABELS          SEMB STANDARD ERROR OF LOGIT ABILITY BETA/
116     VAR LABELS          BETA ABILITY IN LOGITS/
117     VAR LABELS          L    NUMBER OF ITEMS/
118     VAR LABELS          ZB   Z SCORE OF CUT-SCORE FROM BETA/
119     VAR LABELS          PM   PROB OF BEING CLASSIFIED A MASTER/
120     VAR LABELS          PCC  PROP OF CONSISTENT CLASSIFICATION/
121     PRINT FORMATS       TCC,BETA,INFO,SEMB,PM,PCC,(2)
122     LIST CASES          CASES=42/VARIABLES=TCC,BETA,INFO,SEMB,PM,PCC/
123     SCATTERGRAM         TCC(0,42),BETA(-5,5)/
124                         INFO(0,15),BETA(-5,5)/
125                         SEMB(0,5),BETA(-5,5)/
126                         PM(0,1),BETA(-5,5)/
127                         PCC(0,1),BETA(-5,5)/
128     READ INPUT DATA
```


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